

## CLAIMS

1. A volume measuring apparatus comprising:
  - an acoustic tube whose one end is communicated with a container in
  - 5 which an object to be measured is contained;
  - another container communicated with the other end of said acoustic tube;
  - a partition chamber which defines a sealed space disposed adjacent to said another container and which includes a partition plate for dividing the
  - 10 sealed space and an inner space of said another container;
  - an electromotive-type speaker which is disposed in the sealed space and whose acoustic wave output surface is disposed opposite to the partition plate; and
  - a processing device for obtaining a volume of the object to be measured, on the basis of an acoustic signal associated with an acoustic wave outputted into said another container via the partition plate from the acoustic wave output surface.
2. A volume measuring apparatus comprising:
  - 20 a container in which an object to be measured is contained;
  - an acoustic tube (i) whose one end is communicated with said container and (ii) whose the other end is open to surrounding atmosphere;
  - a partition chamber which defines a sealed space disposed adjacent to said container and which includes a partition plate for dividing the sealed
  - 25 space and an inner space of said container;
  - an electromotive-type speaker which is disposed in the sealed space

and whose acoustic wave output surface is disposed opposite to the partition plate; and

a processing device for obtaining a volume of the object to be measured, on the basis of an acoustic signal associated with an acoustic wave outputted into said container via the partition plate from the acoustic wave output surface.

3. A volume measuring apparatus comprising:

a container in which an object to be measured is contained;

10 a plurality of acoustic tubes (i) whose one ends are respectively communicated with said container and (ii) whose the other ends are respectively open to surrounding environment;

a carrying device for carrying the object to be measured into inside of said container via one of said plurality of acoustic tubes and for carrying the 15 object to be measured to outside of said container via the other of said plurality of acoustic tubes;

a partition chamber which defines a sealed space disposed adjacent to said container and which includes a partition plate for dividing the sealed space and an inner space of said container;

20 an electromotive-type speaker which is disposed in the sealed space and whose acoustic wave output surface is disposed opposite to the partition plate; and

a processing device for obtaining a volume of the object to be measured, on the basis of an acoustic signal associated with an acoustic wave 25 outputted into said container via the partition plate from the acoustic wave output surface.

4. The volume measuring apparatus according to claim 1, further comprising: an amplifier, whose type is constant current driving type, for driving said electromotive-type speaker, wherein

5. said processing device includes (i) a measuring device for measuring a voltage of a voice coil associated with said electromotive-type speaker and (ii) a calculating device for calculating the volume of the object to be measured, on the basis of the measured voltage.

10 5. The volume measuring apparatus according to claim 4, wherein  
the calculating device includes (i) a first calculating device for performing a frequency analysis associated with the acoustic signal, on the basis of the measured voltage and (ii) a second calculating device for calculating the volume of the object to be measured, on the basis of a result of  
15 the performed frequency analysis.

6. The volume measuring apparatus according to claim 5, wherein  
the first calculating device determines a resonance frequency associated with the acoustic signal, as a frequency giving a peak in a  
20 spectrum of the measured voltage, and  
the second calculating device calculates the volume, on the basis of the determined resonance frequency.

7. The volume measuring apparatus according to claim 6, wherein  
25 said container contains the object to be measured in an extremely low temperature condition,

an amplifier drives said electromotive-type speaker in constant current condition so as to perform a maximum entropy method (MEM) for a sufficient time period period, and

the first calculating device determines the resonance frequency by the 5 maximum entropy method.

8. The volume measuring apparatus according to claim 1, further comprising: a microphone for receiving the acoustic wave, wherein

10 said processing device obtains the volume of the object to be measured, on the basis of the acoustic signal associated with an acoustic wave received by said microphone.

9. A volume measuring apparatus comprising:

15 an acoustic tube whose one end is communicated with a container in which an object to be measured is contained;

another container communicated with the other end of said acoustic tube;

an electromotive-type speaker whose acoustic wave output surface is disposed facing an inner space of said another container;

20 an amplifier, whose type is constant current driving type, for driving said electromotive-type speaker;

a measuring device for measuring a voltage of a voice coil associated with said electromotive-type speaker; and

25 a calculating device for calculating a volume of the object to be measured, on the basis of the measured voltage.

10. A volume measuring apparatus comprising:

    a container in which an object to be measured is contained;

    an acoustic tube (i) whose one end is communicated with said container and (ii) whose the other end is open to surrounding environment;

5       an electromotive-type speaker whose acoustic wave output surface is disposed facing an inner space of said container;

    an amplifier, whose type is constant current actuating type, for driving said electromotive-type speaker;

    a measuring device for measuring a voltage of a voice coil associated 10 with said electromotive-type speaker; and

    a calculating device for calculating a volume of the object to be measured, on the basis of the measured voltage.

11. A volume measuring apparatus comprising:

15     a container in which an object to be measured is contained;

    a plurality of acoustic tubes (i) whose one ends are respectively communicated with said container and (ii) whose the other ends are respectively open to surrounding environment;

    a carrying device for carrying the object to be measured into inside of 20 said container via one of said plurality of acoustic tubes and for carrying the object to be measured to outside of said container via the other of said plurality of acoustic tubes;

    an electromotive-type speaker whose acoustic wave output surface is disposed facing an inner space of said container;

25     an amplifier, whose type is constant current actuating type, for driving said electromotive-type speaker;

a measuring device for measuring a voltage of a voice coil associated with said electromotive-type speaker; and

a calculating device for calculating a volume of the object to be measured, on the basis of the measured voltage.

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12. The volume measuring apparatus according to claim 1, wherein the object to be measured is fluid, and said volume measuring apparatus further comprises: a separating device for separating the fluid from gaseous phase in a non or minute gravity condition.

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13. A volume measuring method on a volume measuring apparatus comprising: an acoustic tube whose one end is communicated with a container in which an object to be measured is contained; another container communicated with the other end of said acoustic tube; a partition chamber which defines a sealed space disposed adjacent to said another container and which includes a partition plate for dividing the sealed space and an inner space of said another container; and an electromotive-type speaker which is disposed in the sealed space and whose acoustic wave output surface is disposed opposite to the partition plate,

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said volume measuring method comprising:

an outputting process of outputting an acoustic wave into said another container via the partition plate from the acoustic wave output surface; and

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a processing process of obtaining a volume of the object to be measured, on the basis of an acoustic signal associated with the outputted

acoustic wave.

14. A volume measuring method on a volume measuring apparatus comprising: a container in which an object to be measured is contained; an acoustic tube (i) whose one end is communicated with said container and (ii) whose the other end is open to surrounding atmosphere; a partition chamber which defines a sealed space disposed adjacent to said container and which includes a partition plate for dividing the sealed space and an inner space of said container; an electromotive-type speaker which is disposed in the sealed space and whose acoustic wave output surface is disposed opposite to the partition plate,

said volume measuring method comprising:

an outputting process of outputting an acoustic wave into said container via the partition plate from the acoustic wave output surface; and

15 a processing process of obtaining a volume of the object to be measured, on the basis of an acoustic signal associated with the outputted acoustic wave.

15. A volume measuring method on a volume measuring apparatus comprising: a container in which an object to be measured is contained; a plurality of acoustic tubes (i) whose one ends are respectively communicated with said container and (ii) whose the other ends are respectively open to surrounding environment; a carrying device for carrying the object to be measured into inside of said container via one of said plurality of acoustic tubes and for carrying the object to be measured to outside of said container via the other of said plurality of acoustic tubes; a partition chamber which

defines a sealed space disposed adjacent to said container and which includes a partition plate for dividing the sealed space and an inner space of said container; and an electromotive-type speaker which is disposed in the sealed space and whose acoustic wave output surface is disposed opposite to the  
5 partition plate,

    said volume measuring method comprising:

        an outputting process of outputting an acoustic wave into said container via the partition plate from the acoustic wave output surface; and

10      a processing process of obtaining a volume of the object to be measured, on the basis of an acoustic signal associated with the outputted acoustic wave.

16.      A volume measuring method on a volume measuring apparatus comprising: an acoustic tube whose one end is communicated with a container in which an object to be measured is contained; another container  
15      communicated with the other end of said acoustic tube; an electromotive-type speaker whose acoustic wave output surface is disposed facing an inner space of said another container; and an amplifier, whose type is constant current driving type, for driving said electromotive-type speaker,

20      said volume measuring method comprising:

        a measuring process of measuring a voltage of a voice coil associated with said electromotive-type speaker; and

        a calculating process of calculating a volume of the object to be measured, on the basis of the measured voltage.

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17.      A volume measuring method on a volume measuring apparatus

comprising: a container in which an object to be measured is contained; an acoustic tube (i) whose one end is communicated with said container and (ii) whose the other end is open to surrounding environment; an electromotive-type speaker whose acoustic wave output surface is disposed facing an inner space of said container; and an amplifier, whose type is constant current actuating type, for driving said electromotive-type speaker,

5                   said volume measuring method comprising:

                  a measuring process of measuring a voltage of a voice coil associated with said electromotive-type speaker; and

10                a calculating process of calculating a volume of the object to be measured, on the basis of the measured voltage.

18.        A volume measuring method on a volume measuring apparatus comprising: a container in which an object to be measured is contained; a

15        plurality of acoustic tubes (i) whose one ends are respectively communicated with said container and (ii) whose the other ends are respectively open to surrounding environment; a carrying device for carrying the object to be measured into inside of said container via one of said plurality of acoustic tubes and for carrying the object to be measured to outside of said container

20        via the other of said plurality of acoustic tubes; an electromotive-type speaker whose acoustic wave output surface is disposed facing an inner space of said container; and an amplifier, whose type is constant current actuating type, for driving said electromotive-type speaker;

                  said volume measuring method comprising:

25                a measuring process of measuring a voltage of a voice coil associated with said electromotive-type speaker; and

a calculating process of calculating a volume of the object to be measured, on the basis of the measured voltage.